Town of Palm Beach
Phipps Ocean Park - Beach Restoration

Recommended Preliminary Design

Overview

A Conceptual Design for beach restoration at Phipps Ocean Park ("*Reach 7")* was previously identified in a report titled: "*Shoreline Management Recommendations - Comprehensive Coastal Management Plan Update - Palm Beach Island, Florida*" dated September, 1997. This Conceptual Design suggested the placement of 1.16 million cubic yards of sand between DNR Monument R-116 and R-126 at a total estimated construction cost of $9.06 million with 8 groins at an additional cost of $1.64 million. The conceptual project assumed the fill would be the same grain size as native beach sediment so "overfill" volumes were minimal.

The present document summarizes the advancement and refinement of the Conceptual Design to a recommended preliminary design which is to be the basis for permitting and final design. Key elements of this recommended design are:

- placement of 1.5 million cubic yards of sand along 1.9 miles of beach (R-116 to R-126),

- a preliminary beach fill design profile with a berm width varying from 110 to 330 feet with a dry beach width (to MWH) from 180 to 400 feet,

- artificial reef construction for hardbottom mitigation,

- a total estimated project cost of $9.014 million (construction, mitigation and monitoring).

The recommended borrow source includes two sites approximately 3,500 feet offshore and located between 1.5 and 2.6 miles south of the fill area mid-point. The two borrow sites contain sand with composite grain sizes of approximately 0.22 mm and 0.32 mm; the native beach has historically contained 0.34 mm grain size material. Approximately one half-million yards more than the Conceptual Design volume - is proposed to provide sufficient material to maintain a beach along <u>*most*</u> of the project shoreline until the projected renourishment in 8 years. Groins do not appear to be economically justified to reduce fill quantities and/or improve longevity of the beach fill project.

Preliminary Design Development

The preliminary design was developed using a combination of cross-shore and shoreline change numerical model simulations, historical data comparisons and engineering judgments. The following sections outline the design process.

Design Goal and Initial Storm Impact Simulations: The Conceptual Design defines a specific project goal in terms of "*... targeted level of storm protection ... to avoid significant damage from a 15-year return interval storm at any time between the initial restoration ... and subsequent renourishments.*" This statement prescribes the preliminary design criteria.

Two cross-shore transport models, SBEACH and EDUNE, were used to evaluate a 15-year storm event impact to the project area, both with and without the conceptual beach fill. The model results indicated that, although the simulated storm caused profile steepening and some bluff recession, the predicted erosion would not affect the existing dune. In other words, the existing beach provides protection to the upland improvements under *a single* design storm.

Because the design beach criterion largely is met by the existing profile, the construction of a beach fill project would address a corollary goal of acting both as a "feeder beach" and as advanced maintenance against on-going future erosion. In effect, the fill will buffer the existing profile against background erosional losses and allow it to be maintained as the "design beach," satisfying the targeted level of storm protection.

Figure 1 illustrates the existing beach (1999 survey) cross-shore model results at monuments R-125. In subsequent stages of the design process, the cross-shore models were again used to force the initial adjustment of the fill construction template in order to ensure that subsequent shoreline change projections would be based on a waterline position associated with a fully equilibrated profile. This approach adds a reasonable degree of conservatism in the design to deal with the uncertain foreshore slope angle resulting from the borrow area sand's smaller grain size.

Longer-Term Shoreline Change Evaluation: The second stage of the design process was to evaluate the longevity of the fill and to estimate the residual beach widths over time. Hindcast wave data was obtained from the U.S. Army Corps of Engineers (USACE) Waterways Experiment Station (WES) to use as deep water wave input to the wave transformation model RCPWAVE, producing a new time series of nearshore wave conditions. These nearshore wave conditions were then used to drive the shoreline change model, GENESIS. After calibration, the GENESIS model was then applied in iterations to optimize fill placement locations and volumes which offered the best compromise to:

(a) maximize the beach width over eight years - until renourishment,
while, (b) meeting the Town's original budget for the project.

<u>Model</u> <u>Calibration</u>**:** The GENESIS model was calibrated by modeling shoreline changes in the project area over the period from 1975 to 1986 and comparing predicted waterline positions with measured survey data for the period. A summary of the wave data for the period, as processed by the RCPWAVE model, is illustrated in Figures 2, 3 and 4.

The 1975 surveyed shoreline (model input), the model-calculated 1986 shoreline position, and the measured 1986 shoreline are illustrated in Figure 5. Note that the natural shoreline has a significant change in orientation near Monument R-121. This change, in combination with dominant transport from the north, should result in a change in alongshore transport potential and resulting accretion south of R-121, assuming sufficient sand exists in the system to the north to fill the potential.

However, during the historical time frame covered by the model simulation, the shoreline north of Sloan's Curve was armored by a rock revetment by the Florida DOT. In addition, existing groins to the north of the project area diminish actual longshore transport to the project area. To achieve a reasonable model calibration, transport from the north into the project area was limited to less than the calculated potential by establishing a boundary condition in the model that numerically simulated these constraining conditions.

Predicted Fill Performance: The expected performance of the design fill volume and placement location cited in the Conceptual Design was evaluated by using the GENESIS model to calculate the waterline position and residual beach width 8 years after construction. The results indicated the southern portion of the conceptual fill project (R-123 to R-125) would rapidly erode as illustrated in Figure 6 (GENESIS run b11). This projected rapid erosion is attributable to the protruding sandy headland geometry which would result from the placement geometry in the Conceptual Design. The results also indicated rapid erosion along the northern portion of the project attributable to the longshore-transport deficit at the north project boundary.

Coastal Tech adjusted the design to avoid these excessive losses at the southern portion of the project and in recognition of the natural change in shoreline orientation. The evaluation used the same design volume, but adjusted the fill configuration to place a greater amount of the sand in the northern portion of the project (between Monument R-116 and R-122). The adjusted configuration more closely follows the natural shoreline alignment and provides a greater amount of sand near the northern portion of the project where losses are expected to be the greatest. The shoreline changes predicted for two, four, and six years after fill placement using adjusted fill configuration are compared in Figure 7. The results from "weighting" additional fill into the northern portion of the project area indicate that for a design volume of approximately 1 million cubic yards (1.5 million cubic yards with overfill):

- Within 6 years, the shoreline between monuments R-116 and R-117 would erode back to the existing condition (to the existing rock revetment and nearshore rock). This is only approximately 0.21 miles of the 1.9 mile project shoreline.

- Within 8 years, the shoreline would erode back to the existing condition between monuments R-116 and R-118, or about 750 feet north of the north boundary of Phipps Ocean Park. This is only approximately 0.35 miles of the 1.9 mile project shoreline.

Coastal Tech also performed several model runs which simulated placement of fill material within <u>*only*</u> the *currently designated* Critical Erosion Area from R-116 to R-121. The results of these runs showed that the fill would spread rapidly from this limited project area and accrete along the shoreline from R-121 to R-124, remaining there through the simulated time period. This is reflected in Figure 8, which illustrates fill placement within the *currently designated* Critical Erosion Area (R-116 to R-121) with 0.75, 1.125, and 1.5 million cubic yards of sand fill and the projected eight year post-construction shoreline (GENESIS runs b31, b33, and b34). Placement of fill only in this area would be undesirable due to rapid losses throughout the entire initial placement area and the associated public perception of poor project performance. In addition, the projected accretion in the area from R-121 to R-124 might also be perceived as an unintended result of the project, producing a shoreline advancement/benefit not recognized by the public or the DEP as being related to the project's public funding.

As requested by DEP staff, an additional model run was performed which included fill only between R-116 and R-124. The result of this model run, a 1.5 million cubic yard fill with the associated projected eight year post-construction shoreline (GENESIS run b39), is shown on Figure 9. This fill configuration also shows the rapid losses in the northern portion of the project and advancement of the downdrift shoreline, in this case, from R-121 to R-126. Again, because of potential poor public perception and lack of recognition for benefited beaches outside of the specific project area, this project configuration does not optimize project performance and is not recommended.

The optimal project performance for this segment of the Town beaches is achieved with fill placed in the extended area as adjusted and proposed by Coastal Tech (R-116 to R-126). Fill placed in this recommended configuration still spreads, although somewhat less rapidly, from the northern section of the project area, and reinforces the fill also placed from R-121 to R-126 (see Figure 6, GENESIS run b37). This geometry confines the losses to only the northern-most portion of the fill area and should aid in the perception of excellent project performance within the public park. In addition, initial fill placement in the area from R-121 to R-126 would result in creation of a more stable shoreline with direct recognition of the benefits of State funding in that area.

DEP historical shoreline data has been reviewed by Coastal Tech to document the significant shoreline recession along the segment of this project area which has not been designated as a Critical Erosion Area (R-121 to R-126). Figure 9, *("Shoreline Change (MHW) Over Time")* clearly demonstrates the historical shoreline recession from 1883 to 1990, identifying a MHW change ranging from approximately 140 feet at R-122 to approximately 100 feet at R-123. This data supports the conclusion that this section of beach suffers from a longshore transport deficit. The physical processes can be expected to exacerbate the future erosion problem within the segment.

Groin Evaluations: In general, from an economic perspective, the use of groins within a fill project can sometimes be justified to reduce losses and future renourishment costs. The Conceptual Design, as presented in the *1997 Plan*, identified the possible use of 8 “T-head” groins beginning at the north limit of Phipps Ocean Park and extending south of the park for approximately 1,000 feet. Coastal Tech used the GENESIS model to assess the effect of conventional “straight” groins on fill performance using the groin spacing suggested in the Conceptual Design and one alternative configuration emerging from our analysis of early “fill-only” shoreline change results. This alternative, “Coastal Tech Design with Structures” places the groins beginning approximately 700 feet north of Phipps Ocean Park ending about 400 feet south of the park. For all simulations, permeable rock groins (ñ = 0.10%) with a crest at approximately elevation +5.0 NGVD and extending 150 feet seaward of the 1999 shoreline were assumed. The relative performance of the Conceptual Design groin location/spacing and the Coastal Tech alternative configuration is characterized by the GENESIS model results presented in Figure 6.

Groin effects were simulated for both the Conceptual Design beach fill and the adjusted beach fill proposed by Coastal Tech. For both of these fill conditions, groins south of the park do not become exposed by the modeled erosion within the simulation period and, therefore, have no positive effect. Groins in the more northerly section become exposed and affect fill performance in the early years of the simulation, but the net reduction in fill losses at the renourishment interval are marginal.

For the Coastal Tech alternative design with groins, as illustrated in Figure 6, only minor pocket beaches (additional dry beach width of 20 feet±) would remain 8 years after initial nourishment in front of the northern half of Phipps Ocean Park. The additional width would extend over a shoreline length of about three groins, or roughly 1400 linear feet. Using a purely volumetric analysis, the positive effect of the groin would be to preserve an additional 10,000 cubic yards of sand which would *not* have to be replaced during each renourishment.

With the unit cost of sand estimated for the initial project at $4.50 per cubic yard, and assuming 3% allowance for inflation per year, this groin benefit translates into a cost avoidance of approximately $57,000 in year eight. Similar calculations could be made for future 8-year renourishment cycles, but clearly it would take in excess of a typical 50-year project life cycle to recover the $1M+ cost of the groins, which suggests that their use is not cost effective.

A comprehensive evaluation of “T-head” groins was beyond the scope of this report. However, from the negligible benefits predicted by the model results for the simplified, more conventional “straight” groin case, any “T-head” groins would likely have to be extremely long and large to affect the processes sufficiently to hold any substantial amount of beach material.

Borrow Material Effects: The shoreline change modeling described above evaluated a project having a nominal design fill volume of 1 million cubic yards as proposed in the Conceptual Design. The next stage in the design process was to adjust the fill volume to treat the differences in performance which might result from differences in grain size between the borrow and native sand.

The existing native material composite grain size has been measured at 0.395 mm. However, comparisons with the sand grain size on adjacent beaches suggest that this area may be better represented by a grain size of 0.34 mm. The Corps of Engineers conducted a preliminary investigation of native sand along Palm Beach County beaches in 1961. The results of this investigation provide a historical representation of the sand characteristics of the beaches within the area which included this project. According to the results, South Palm Beach County has a mean grain size of 0.34 mm and is moderately sorted. This section of Phipps beach might be characterized as “stressed”, having the highest erosion rate of all the Town beaches. It has been observed that beaches in this condition can lose to erosion over time a larger volume of the finer-grained portion of their gradation, and as a result retain only the larger grain size material. For the purposes of this design a grain size of 0.34 mm was used to describe the native sand size.

Based on the borrow area geotechnical data provided by CP&E, the proposed borrow area contains sand with smaller composite mean grain sizes (0.22 mm and 0.32 mm) as compared to the native beach (0.34 mm). An “overfill factor,” expressed as a ratio, establishes some additional volume of finer-grained borrow material which would be necessary to produce a specific design volume of native beach material. The *Concept Plan* construction volume was based on an overfill ratio of between 1.0 and 1.2, which essentially assumed the borrow material would be the same size as the native. The actual overfill ratios calculated for the sands in the two sites identified by CP&E is about 1.2 for the 0.32 mm material, and about 3.4 for the 0.22 mm material.

> The application of these overfill factors to the design fill of 1 million cubic yards would result in a required total project quantity of about 2.1 million cubic yards. If the total project volume is limited to 1.5 million cubic yards in order to generally stay within the project budget established under the assumptions contained in the Conceptual Design, the result would be to effectively place *less* than the design fill of 1 million cubic yards. After proportioning the calculation for the two different borrow sizes, and assuming all of the 0.32 mm material will be used, the net effect of limiting the cost would be equivalent to placing a design fill of roughly 800,000 cubic yards of native sand. From our modeling experience the practical result would be that slightly more of the northern shoreline of the area would erode back to the existing condition within the 8-year renourishment period. The general geometry of the rest of the shoreline and the *average* performance of the fill would not be dramatically affected by the difference in assumed design volume.
>
> If additional funding can be made available, Coastal Tech supports the placement of additional sand volume up to the calculated 2.1 million cubic yard requirement. However, if the present budget target is preserved, the difference in overall average project performance at the 8-year maintenance point would *not* be sufficiently great that we would recommend against proceeding with the project because of concerns over excessive losses.

The permit sketches, located in Appendix L illustrate the proposed borrow area cuts for initial construction.

Cross-Shore Profile Adjustment: After the fill is initially placed, the beach will rapidly adjust to come into equilibrium with the ambient bottom conditions, wave climate and composite grain size. For purpose of estimating this adjustment and its effect, the SBEACH model was applied to the anticipated construction fill under the influence of a 15-year return interval storm event. Figure 10 illustrates the projected initial adjustment which is estimated to be a landward migration of the shoreline of about 90 feet at MHW. This adjustment incorporates the effects of moving from an excessively steep initial construction profile to a more “natural” slope, *plus* some of the effect of the fill grain size on establishing that final slope angle. In one sense this might not be viewed as net volumetric erosion, because the original volume will remain in the (submerged) nearshore area. However, because of the rapid decrease in dry beach width it would be perceived publicly as erosion.

Hardbottom Impacts: The toe of the fill extends approximately 430 to 570 feet offshore and is expected to impact approximately 1.5 acres of nearshore hardbottom. As of this date, the biological productivity of the existing hardbottom has been characterized as follows:

- Only a small amount of hardbottom appears to exist north of, and outside of, the limits of the project (DNR Monument R-113 to R-115).
- A minor amount of inverted relief exists which appears to be very susceptible to burial by sand due to natural occurrences.
- A maximum relief of 2 to 3 feet exists, which is relatively smooth rock with a blanket of algae and sediment.
- Epibiota coverage is low, with less than 20% coverage expected after final analysis.
- Reef building worms occur, although not well developed and not extensive.
- Sponges, hard coral, and soft coral exist as very small colonies.
- The fish population does not appear to be well developed, they are mostly transient fish and will not be affected by the project.
- The emergent rock formation that exists on shore (from R-116 to R-123) does not support significant biota.
- There does not appear to be any hardbottom formation from R-123 to the southern limits of the project (R-126), however, an assessment of this area will be included in the final hardbottom survey report.

The extent of hardbottom that may warrant mitigation can be more accurately assessed upon completion of the hardbottom surveys. In so far as this hardbottom is immediately adjacent to the shoreline, project impacts associated with placement of beach fill are unavoidable.

Opinion of Probable Costs: Estimates of the probable construction costs were developed from comparison of recent (within the past 7 years) beach fill projects which have been constructed in the vicinity of the project area. These projects represent work of a similar scope and provide a reasonable estimation of the cost to perform a beach fill project of similar scope to this proposed project. Table 1 (compiled by CP&E, April 1998) summarizes the projects and their costs. The unit cost for dredging and placement of sediment for the Phipps Ocean Park Project includes an increase for contingencies and inflation. The unit cost for the proposed project is estimated at $4.50 per cubic yard. Total costs for a 1.5 million cubic yard project are estimated at $9.014 million; for a 2.1 million yard project the cost estimate would be $11.7 million.

Table 1
Recent Hydraulic Cutterhead Dredge Projects

Project	*Year*	*Sand Size*	*Maximum Pipe Length*	*Nominal Water Depth of Borrow Area*	*Approximate Dredge Cut*	*Actual Unit Cost*
Delray Beach	1992	0.27 mm	1.25 miles	30-40 ft.	20 feet	\$3.01
Midtown	1995	0.30 mm	5.0 miles	30-40 ft.	10 feet	\$3.23
Jupiter/ Carlin	1995	0.38 mm[1]	1.75 miles	10-25 ft.	7.5 to 20 feet	\$3.30
Martin Co. 4 mile[2]	1995		5.25 miles			\$5.26
Boca Raton	1998	0.26 mm	1.5 miles	45-55 ft.	5 to 20 feet	\$3.00

1. As indicated in the GDM, actual sand was finer
2. A booster pump was utilized for this project